Effect of Storage and Railroad Transit on Potato Diseases, Injuries, and Shrinkage

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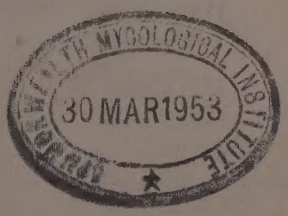

This study was part of a Northeast Regional Project on marketing and distribution of potatoes. Cooperating in the study were the United States Department of Agriculture—Div. of Handling, Trans., and Storage of Hort. Crops of the Bur. Plant Ind., Soils, and Agr. Eng.; the Maine Department of Agriculture; and the Maine Agricultural Experiment Station.

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SUMMARY

This bulletin describes changes that occurred in diseases and defects in potato shipments from Northeastern Maine to New York City during the period of 1947 to 1949. Shipment was by railroad refrigerator cars supplied with heating service. The average temperature in test bags, as determined by recording thermometers, was 49° F. This temperature was based on 20 carloads in transit for an average of seven days.

Twenty-two shipments of 50-pound bags put up by commercial methods from the 1949 crop had an average net weight in Maine of 49.20 pounds of potatoes with adhering dirt, and 48.45 pounds in New York City. This meant an original shortage of 1.6 per cent and a transit shrinkage of 1.5 per cent. Deterioration of several kinds occurring in transit was sufficient to cause potatoes that were in-grade at shipping point to be out-of-grade at destination.

Changes occurring in transit were varied. Late-blight affected tubers lost more weight than healthy tubers in the same samples. Soft rot and evident fusarium rot increased in samples containing late-blight rot. Ring rot usually increased in both prevalence and severity. Net-necrosis severity often increased significantly. Stem-end browning sometimes increased significantly in severity. Mahogany browning sometimes increased significantly in prevalence, amount, and severity. The larger tubers showed a greater precentage of surface area covered by early-blight lesions and showed more prevalent and severe mahogany browning. Fresh bruise cracks, incurred during grading, in part healed and in part became more conspicuous and scorable. In stocks containing bacterial soft rot which had been "cleaned" with rubber brushes and sawdust, scorable lesions and soft rot increased considerably. Early-blight lesions became less severe. Washed potatoes showed no change in transit.

In making this study, certain procedures were found to be usually desirable for reliability. These were: (a) duplication of a series of samples, (b) examination by the same person at shipping point and destination, (c) adaptation of sample size and method of examination to the kind of disease or defect being studied, and (d) objective classification of tubers. One-hundred-pound samples yielded significant differences in net necrosis somewhat more often than 50- or 25-pound samples. The use of Student's method also increased the number of significant differences in net necrosis.

Studies were made previously on net necrosis and stem-end browning, and concurrently on mahogany browning, in controlled-temperature storages. These were compared with in-transit studies and found to be highly indicative of tuber changes occurring in transit.

BULLETIN 507

EFFECT OF STORAGE AND RAILROAD TRANSIT ON POTATO DISEASES, INJURIES AND SHRINKAGE[1]

DONALD FOLSOM, HARRY Q. ROACH, JAMES S. WIANT, AND J. KAUFMAN[2]

INTRODUCTION

The primary purpose of this study was to learn what changes in diseases and defects occurred in potatoes during railroad transit from Aroostook County, Maine, to New York City. The data were expected to show whether differences between shipping-point and unloading-point inspections could be due to changes in the potatoes in transit rather than to differences between the work of one inspector and that of another.

The information was also expected to test the value of experiments in Maine storage bins, in which the temperature was controlled, as compared to in-transit study of changes in potatoes. Incidentally, relationships were disclosed between tuber size and the incidence and severity of mahongany browning and the severity of early-blight rot.

DISEASES STUDIED

The diseases studied were late-blight rot (*Phytophthora infestans*), early-blight rot (*Alternaria solani*), fusarium rot, ring rot (*Corynebacterium sepedonicum*), bacterial soft rot, leafroll net necrosis, virus stem-end browning, and mahogany browning (induced by several months' exposure to low temperatures next to the outside walls of storage bins). Some attention also was given to bruise cracks incurred during grading, "cleaning" potatoes with rubber brushes and sawdust, and washing.

The diseases studied are described in several general bulletins on potato diseases (*3, 4, 7, 14*).[3] The diseases are discussed in relation to storage and transportation of potatoes by Rose and Cook (*15*).

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[1] This study was part of a Northeast cooperative regional project on marketing and distribution of potatoes.

[2] The authors were, respectively: Plant Pathologist in the Maine Agr. Exp. Sta.; collaborator in the Div. Mkts. of the Maine Dept. Agr.; and Senior Pathologist and Asst. Pathologist in the Div. Handling, Transportation, and Storage of Hort. Crops of the Bur. Plant Ind., Soils, and Agr. Eng., U.S.D.A.

[3] Numbers in italics refer to Literature Cited at the end of this publication.

GENERAL METHODS

Usually three things were done in relation to each shipment: (1) duplicate series of samples were taken; (2) one series was examined at the shipping point; and (3) the other series was examined by the same person at the unloading point. The examiner usually was the second author, an official inspector. In some instances the second author was assisted by the first author or was replaced by him. Examination of duplicate samples by the same person was considered highly desirable. A problem of obtaining uniformity of inspection was found in Oregon (*2,* p. 14) and was reduced there by using the same inspector at shipping point and terminal market (*1,* p. 8, *2,* p. 14, *10,* p. 4).

As pointed out by Perry and Merchant (*13,* p. 12), "in studies of this nature, where the direction of the findings may be logically predetermined at the outset, there is always the danger that some workers may be biased in the direction of the logical conclusion." In this study, each potato was examined carefully and classified, usually according to an objective standard, and the data were summarized by weight or by number of tubers for each bagful. The recorded weights were used later to determine means, probable errors, and statistical significance of the differences.

Each stock was selected for the study of one disease, as a rule. The samples ranged from 10 to 100 pounds per bag. As the samples were taken from the grader or bin, they were numbered consecutively. Then the odd-numbered bags were set aside for the shipping-point examination and the even-numbered bags were put into a car destined for New York City. A stored stock could be sampled even though not being commercially graded and shipped. It was not necessary to ship the samples with stock from the same bin, or in a car loaded at the storage place. For example, a farm storage might contain stock with too much disease for profitable grading, but might be very desirable for this study and samples could be taken. Part of these would be examined on the spot and the rest transported by auto to a railroad car being loaded for shipment. It was usually a case of locating a suitable stock and then finding a car in which it could be shipped to New York City. All shipments were in refrigerator cars supplied with heating service.

A Ryan recording thermometer was placed in a bag in all but a few of the series shipped. The departure and arrival dates were recorded for each shipment. Usually five stocks were sampled, shipments started, and the Maine examination made in the course of a few days. Then the examiner traveled to New York City and made his examinations in the Market Pathology Laboratory there. Perry and Merchant have pointed out (*13,* p. 26) that lighting conditions can influence inspec-

TABLE 1

General Data on Test Potato Samples Shipped from Aroostook County, Maine, to New York City

Stock no.[1]	Variety[2]	Chief disease (or process)[3]	Bags		Transit			
			No. per series[4]	Average weight[5]	Date of start	Days	Temperature[6]	
							Range	Average
				lbs.			°F.	°F.
47–A	Gr. Mt.	NN	10	100	2/23	8	45-50	48
47–B	Gr. Mt.	NN, SEB	10	100	2/24	7	44-52	48
47–C	Ir. Cob.	NN, SEB	10	100	2/25	8	37-46	43
47–D	Kat.?	MB	10	10	4/16	13[7]	[8]	
47–E	Chip.	MB	10	10	4/17	12[7]	[8]	
47–F	Kat.	MB	8	15	4/19	10[7]	[8]	
47–G	Kat.	MB	10	10	4/20	9[7]	[8]	
47–H	Chip.	MB	10	10	4/22	11[7]	[8]	
48–A	Gr. Mt.	SEB	15	15	1/8	6	51-75	65
48–B	Gr. Mt.	NN, SEB	15	15	1/8	6	51-75	65
48–C	Kat.	CRS	10	50	1/5	8	43-51	47
48–D	Gr. Mt.	SEB	15	15	1/8	6	51-75	65
48–E	Gr. Mt.	NN, SEB	10	100	1/5	8	42-51	47
48–F	Gr. Mt.	NN, SEB	15	15	2/8	8	49-61	52
48–G	Kat.	EBR	10	15	2/8	8	49-61	52
48–H	Gr. Mt.	NN, SEB	15	15	2/8	8	49-61	52
48–I	Kat.	CRS	10	50	2/15	7	43-54	51
48–J	Kat.	MB	15	15	5/4	9	56-60	58
48–K	Kat.	MB	15	15	5/4	9	56-60	58
48–L	Kat.	MB	15	15	5/4	9	56-60	58
48–M	Kat.	MB	15	10	5/4	9	56-60	58
48–N	Chip.	MB	15	15	5/4	9	56-60	58
48–O	Chip.	MB	15	15	5/4	9	56-60	58
49–A	Kat.	RR	10	50	11/26	7	40-47	42
49–B	Chip.	LBR	10	50	11/26	7	40-47	42
49–C	Mohawk	NN	10	50	11/26	7	40-47	42
49–D	Gr. Mt.	NN	10	50	11/28	8	43-62	47
49–E	Gr. Mt.	NN	10	50	11/28	8	43-62	47
49–F	Ir. Cob.	SEB	10	50	12/20	9	46-62	52
49–G	Gr. Mt.	NN	10	50	12/17	5	39-45	42
49–H	Gr. Mt.	NN	10	50	12/17	5	39-45	42
49–I	Kat.	LBR	10	50	12/17	5	46-52	49
49–J	Ir. Cob.	LBR	10	50	12/20	9	46-62	52
49–K	Kat.	RR	10	50	1/19	7	49-58	54
49–L	Kat. & Chip.	RR	10	50	1/18	8	45-56	52
49–M	Gr. Mt.	NN	10	50	1/18	8	45-56	52
49–N	Ir. Cob.	NN, SEB	10	50	1/18	8	45-56	52
49–O	Kat.	LBR	10	50	1/19	7	49-58	54
49–P	Chip.	LBR	10	50	2/16	6	43-54	50
49–Q	Gr. Mt.	NN	10	50	2/16	6	43-54	50
49–R	Gr. Mt.	NN	10	50	2/16	6	43-54	50
49–S	Kat.	CRS	10	50	2/22	6	42-51	47
49–T	Kat.	W	2	50	2/22	6	42-51	47
49–U	Chip.	CRS	10	50	3/23	5	41-52	45
49–V	Gr. Mt.	NN	10	50	3/23	5	41-52	45
49–W	Kat.	RR	10	50	3/23	5	41-52	45
49–X	Kat.	RR	10	50	3/28	6	41-46	43
49–Y	Gr. Mt.	NN	10	50	3/28	6	41-46	43
49–Z	Kat.	MB	15	15	3/28	6	41-46	43
49–AA	Kat.	MB	15	15	4/27	5	43-48	44
49–BB	Chip.	MB	15	15	4/27	5	43-48	44
49–CC	Kat.	MB	15	15	4/27	5	43-48	44
49–DD	Chip.	MB	15	15	4/27	5	43-48	44
49–EE	Kat.	MB	15	15	4/27	5	43-48	44

[1] First part of no. indicates year in which stock was grown (1947 etc.).
[2] Chip. denotes Chippewa; Gr. Mt., Green Mountain; Ir. Cob., Irish Cobbler; Kat., Katahdin.
[3] BC denotes bruise cracks· CRS, "cleaning" with rubber brushes and sawdust; EBR early-blight rot; LBR, late-blight rot; MB, mahogany browning; NN, net necrosis; RR, ring rot; SEB, stem-end browning; W, washing.
[4] Usually one series examined in Maine and another in New York City.
[5] Intended and approximate weight per bag.
[6] Temperature recorded by Ryan thermometer in a bag of tubers.
[7] Including brief time in storage in New York City.
[8] No Ryan thermometer available.

tors' interpretation of defects. For our work we had our own extension cord and light in order to have sufficient lighting where adequate facilities were not already provided.

The method of sampling, size of samples, and method of examination, which were modified so as to be appropriate for each disease or defect, are described below. Certain other data are in Table 1.

As indicated, Ryan thermometers were placed in sample bags before shipment. From the continuous record obtained, the lowest, average, and highest of the daily mean temperatures were determined after calibration of the thermometers in New York. The temperature range and the average were obtained in 20 carloads, containing 49 shipments. These data and the days in transit are listed in Table 2 according to month and day.

TABLE 2

Temperature in Transit of 49 Test Lots in 20 Cars[1]

Shipping date[2]	In transit		
	Days	Temperature[3]	
		Range	Av.
		°F.	°F.
11/26/49	7	40-47	42
11/28/49	8	43-62	47
12/17/49	5	39-45	42
12/20/49	9	46-62	52
1/5/49	8	42-51	47
1/6/49	8	43-51	47
1/8/49	6	51-75	65
1/18/50	8	45-56	52
1/19/50	7	49-58	54
2/8/49	8	49-61	52
2/15/49	7	43-54	51
2/16/50	6	43-54	50
2/22/50	6	42-51	47
2/23/48	8	45-50	48
2/24/48	7	44-52	48
2/25/48	8	37-48	43
3/23/50	5	41-52	45
3/28/50	6	41-46	43
4/27/50	5	43-48	44
5/4/49	9	56-60	58
Average	7.05	44.1[4]-54.2[5]	48.9

[1] Including all shipments listed in Table 1 with temperature recorded.
[2] Arranged according to month and day regardless of year.
[3] Based on daily temperature records from continuously recording Ryan thermometer shipped in a sample bag and calibrated in New York.
[4] Average of minimum temperatures.
[5] Average of maximum temperatures.

The number of days in transit averaged seven. Transit temperatures averaged 49° F. with the highs averaging 54° and the lows 44°. There is no marked relation between month of shipment and average temperature except that the highest (65°) was in a carload shipped

January 8 and the carloads shipped January 8 to February 16 included most of the carloads with average temperature above 48°.

Usually the mean of a set of readings for a series of bags was determined and the P. E. M. (probable error of the mean) calculated as $\chi 1 \sqrt{\text{mean square} - m^2}$. The probable error for the difference between the means for two series was evaluated as the square root of the sum of the squares of the two probable errors. This difference should have odds of over 30 to 1 to be significant. (See *8*, p. 42, or *12* for table of odds according to ratio of the difference to its probable error.)

Student's method (*11*) sometimes was preferable for comparing two series of bags because of the possibility that as the bags came off the grader they would show differences in disease content depending on the part of the bin drawn from. Pairings were made between bags 1 and 2, 3 and 4, etc.

LATE-BLIGHT ROT AND ASSOCIATED SECONDARY ROTS

Five stocks of the 1949 crop were sampled between November 17 and February 16, which was past the incubation period of late-blight rot resulting from infection at digging time. Each tuber was "scored"

TABLE 3

Transit Changes in Late-Blight Rot and Certain Associated Rots

Disease class	Stock[1]	Percentage[2] in Maine	Percentage[2] in New York	Difference[3]	Approximate odds[4]
Late-Blight Rot	49–B	24.99±1.91	23.82±2.18	−1.17	—
	49–I	41.15±1.47	35.61±1.09	−5.54	—
	49–J	3.33±0.30	2.90±0.21	−0.43	—
	49–O	34.13±1.07	33.21±1.10	−0.92	—
	49–P	9.11±0.74	9.10±0.37	−0.01	—
Late-Blight Rot and Fusarium Rot	49–B	0.69±0.16	5.02±0.66	+4.33±0.68	20,000+:1
	49–J	0.55±0.14	1.16±0.22	+0.61	—
	49–O	1.05±0.18	1.09±0.16	+0.04	—
	49–P	0.79±0.16	1.90±0.35	+1.11	—
Late-Blight Rot and Bacterial Soft Rot	49–B	0.23±0.06	2.19±0.42	+1.96±0.42	600:1
	49–I	0.00	1.06±0.28	+1.06±0.28	90:1
	49–J	0.10±0.06	0.45±0.09	+0.35±0.11	30:1
	49–O	0.00	1.36±0.27	+1.36±0.27	1350:1
	49–P	0.20±0.09	3.09±0.30	+2.89±0.31	Infinite
Fusarium Rot	49–B	0.34±0.11	0.96±0.12	+0.62±0.16	110:1
	49–J	0.00	0.10±0.06	+0.10	—
	49–P	1.10±0.18	1.82±0.24	+0.72	—
Bacterial Soft Rot	49–B	0.03±0.02	0.51±0.11	+0.48±0.11	300:1
	49–I	0.10±0.06	0.11±0.07	+0.01	—
	49–J	0.00	0.55±0.12	+0.55±0.12	500:1
	49–P	0.40±0.14	1.33±0.20	+0.93±0.24	110:1

[1] See Table 1 for certain data on each stock.
[2] Mean of series, based on percentage, of each bagful by weight, which consisted of affected tubers.
[3] New York percentage over or under Maine percentage.
[4] If under 30:1, not significant and not given.

(declared out of grade) if it had late-blight rot or if it showed one or more fusarium or bacterial soft rot lesions over ⅛ inch in diameter. The total weight of tubers thus scored in the various disease classes was determined for each bag. The mean percentages are given in Table 3. In all five stocks, the percentage, by weight, showing late-blight rot decreased because transit shrinkage was greater in affected tubers. The percentage of late-blight-rot stock with secondary fusarium rot increased, significantly in one stock. The percentage of late-blight-rot stock with secondary bacterial soft rot increased significantly in all stocks. The percentage of stock with no late-blight rot but with fusarium rot or soft rot also increased in some stocks, often significantly. In each class of tubers, the transit changes showed no apparent relation to variety or average transit temperature (as given in Table 1).

EARLY-BLIGHT ROT

Early-blight rot was found in a Katahdin stock (48-G). Fifty pounds of tubers were examined carefully and each early-blight lesion was marked with an indelible pencil to indicate the limits or margin of the lesion. In New York the same tubers showed no increase in the size of the lesions, but the lesions were more dried out and less raised than in Maine.

In the duplicate series taken from this stock, the tubers in each bag were examined in order of decreasing apparent size. For each tuber an estimate was made of the percentage of surface consisting of lesions. The estimate was made with the help of standard scales or diagrams with known percentages shaded. (Fig. 1.) Then each tuber was sliced through the lesions at right angles to the surface and an estimate was made of the average thickness of lesions in mm. The results are given in Table 4. After transit there was a significant decrease in percentage of surface covered by lesions and in average thick-

TABLE 4

Transit Changes in Early-Blight Rot (Stock 48-G)

Characteristic[1]	In Maine	In New York	Difference[2]	Odds[3]
Percentage of tuber surface covered by lesions	5.76±0.41	4.79±0.32	—0.97	81:1
Average thickness of lesions in mm	2.62±0.12	2.17±0.04	—0.35	30:1

[1] Measured for each tuber, and mean calculated for all tubers in each bag; then bag means used to get series mean.
[2] New York mean over or under Maine mean.
[3] Odds given are those obtained by Student's method; odds obtained by the probable-error method were less than 30:1.

FIGURE 1. Chart (reduced) for classifying potato sections or exteriors as to extent of damage by lesions. Each number denotes percentage of area darkened. The original drawing was made on cross-section paper whose lines were filtered out when the negative was made. Various enlargements were made for use with tubers of different sizes.

ness of lesions, the lesions having become dried and less conspicuous. The tuber records were also used to get the coverage mean for the larger tubers of each bag and for the smaller ones, each class consisting of half of the total tubers. The coverage means were:

In Maine, larger tubers, 6.3%; smaller tubers, 5.2%
In New York, larger tubers, 5.7%; smaller tubers, 4.0%

Thus the larger tubers had a somewhat greater proportion of the surface covered by lesions than the smaller.

RING ROT

Five stocks were sampled for a study of ring rot. Each tuber was examined for external symptoms. It was then sliced at the stem end to

disclose internal symptoms. These, when very mild, consisted of a slight yellowing in the xylem ring with cleavage appearing between pith and cortex when pressure was exerted on the outside of the tuber. Three disease classes were established for the five stocks of tubers. Each tuber was classified as having (1) both external and internal symptoms, (2) internal symptoms only, or (3) no symptoms. This was done for each bag. Each class of tubers was weighed and its percentage by weight determined. The percentages are shown in Table 5. Four stocks showed a decrease in the internal-symptom class. However, with three of them

TABLE 5

Transit Changes in Ring Rot

Symptoms[1]	Stock[2]	Percentage[3] in		Difference[4]	Approximate odds[5]
		Maine	New York		
External and internal[1]	49-A	[illegible]	[illegible]	[illegible]	[illegible]
	49-K	[illegible]	[illegible]	[illegible]	—
	49-L	[illegible]	[illegible]	[illegible]	[illegible]
	49-W	[illegible]	[illegible]	[illegible]	—
	49-X	[illegible]	[illegible]	[illegible]	—
Internal only	49-A	[illegible]	[illegible]	[illegible]	—
	49-K	4.8[illegible]±0.27	1.9[illegible]±0.19	−2.9[illegible]±0.33	Infinite
	49-L	[illegible]	[illegible]	[illegible]	—
	49-W	[illegible]	[illegible]	[illegible]	—
	49-X	[illegible]	[illegible]	[illegible]	—
Total (external and internal, plus internal only)	49-A	7.78±0.53	11.18±0.86	+3.40±1.02	49:1

[1] Exterior symptoms consisting of cracks.
[2] See Table 1 for certain data on each stock.
[3] Mean of series, based on percentage, of each bagful by weight, which consisted of affected tubers.
[4] New York percentage over or under Maine percentage.
[5] If under 30:1, not significant and not given.

(49-L, -W, and -X), this decrease was more than compensated for by an increase in the class with both external and internal symptoms, indicating an increase in the severity of the disease in transit. A fourth stock (49-A) showed an increase in each class, the total ring rot percentage increasing significantly from about 8 to about 11 per cent, the samples having been in transit seven days at 42° F. No relation between average transit temperature and change in total ring rot percentage is apparent in the five stocks, judging from the following comparison:

Stock	49-A	49-X	49-W	49-L	49-K
Temperature	42° F.	43° F.	45° F.	52° F.	54° F.
Ring rot	+3.40%	+0.42%	+0.90%	+1.62%	—1.90%

BRUISE CRACKS

A few Katahdin tubers were taken from the grader and fresh bruise cracks on them were marked with an indelible pencil. On arrival in New York, most of the cracks had healed and were not noticeable. However, some tubers were scorable by inspectors' standards in New York for cracks which were not noticed in Maine at the time of grading.

INJURIES AND DISEASE ASSOCIATED WITH "CLEANING" BY MEANS OF RUBBER BRUSHES AND SAWDUST

In December, 1948, a series of samples was taken from a Katahdin stock affected with soft-rot pitting. Some tubers apparently had soft rot where the distal tuber end had been frozen in the field. Some tubers were completely rotted, many were wet, and others had small, rather dry lesions, soft-rot lesions or pits, or bruise cracks, or were apparently intact or healthy. Isolations from the pits all yielded cultures of soft-rot bacteria. The potatoes at shipping point were being put over a tandem series of three brushers, each of which contained rolls with projecting rubber teeth. Damp sawdust was shovelled onto the tubers on the brushers. The potatoes were moved along slowly by the rolls, which revolved and scrubbed much of the mud and sawdust off the tubers. Some of the mud and sawdust mixture was rubbed into the bruise cracks, eyes, and stolon scars of the tubers; even small pebbles were forced inside the tubers. Some of the mixture clung to the rubber rolls between the teeth and was cleaned off occasionally with the end of a board. The sawdust and dirt mixture accumulating under the brushers was shovelled onto the tubers along with some fresh sawdust. The tubers were still damp on the third brusher and in the bags, but were considerably cleaner looking than when removed from the bin. Tubers thus "cleaned" were examined and classified as indicated in Table 6.

Samples of stock 48-C were shipped in early January with transit temperature averaging 47° F. These had about 21 per cent healthy tubers in Maine. All tubers were affected when the shipment reached New York. This difference was highly significant, as were increases in scorable bruises and scorable lesions. Stock 48-I, shipped in the latter part of February with transit temperature averaging 51° F., had about 10 per cent of the tubers healthy in Maine, but only one per cent in New York. This difference was highly significant. There was a highly significant increase in the class of tubers with scorable lesions and also in the class of tubers with scorable lesions with soft rot. Decreases in the bruise classes merely reflect transfer from these classes to lesion classes.

TABLE 6

Comparison of Defects in Maine and New York in Soft-Rot Infected Stock "Cleaned" with Sawdust and Rubber Brushes Before Packing

Stock[1]	Condition[2]	Percentage[3] in		Difference[4]	Odds[5]
		Maine	New York		
48-C	Healthy	20.9±1.7	0.0	−20.9±1.7	Very high
	Nonscorable bruises	25.2±1.4	27.7±1.1	+2.5	
	Nonscorable lesions	45.4±2.6	49.6±1.4	+4.2	
	Scorable bruises	4.0±0.4	11.5±0.4	+7.5±1.2	1350−:1
	Scorable lesions	3.4±0.4	10.6±0.9	+7.2±1.0	Very high
	Scorable lesions with soft rot	0.8±0.2	1.4±0.2	+0.6	
48-I	Healthy	9.8±0.7	1.0±0.2	−8.8±0.7	Very high
	Nonscorable bruises	31.4±0.8	19.3±1.3	−12.1±1.5	Very high
	Nonscorable lesions	31.2±0.9	35.4±1.5	+4.2	
	Scorable bruises	10.5±0.7	6.7±0.6	−3.8±0.9	216:1
	Scorable lesions	12.3±1.0	21.7±1.4	+9.4±1.7	1350+:1
	Scorable lesions with soft rot	4.8±0.9	15.7±2.0	+10.9±2.2	1350:1
49-S	Healthy	49.32±0.59	34.10±1.52	−15.22±1.63	Very high
	Nonscorable bruises	30.53±0.77	23.58±0.82	−6.96±1.12	Very high
	Nonscorable lesions	11.18±0.42	22.22±1.08	+11.04±1.16	Very high
	2 preceding	41.75±0.54	45.80±1.11	+4.05±1.23	30:1
	Scorable bruises	4.50±0.43	8.84±0.53	+3.48±0.68	1350−:1
	Scorable lesions	4.23±0.32	10.64±1.08	+6.41±1.13	1350+:1
	Scorable lesions with soft rot	0.15±0.07	1.41±0.24	+1.26±0.25	1350:1
	3 preceding	8.94±0.48	20.10±1.25	+11.16±1.34	Very high
49-U	Healthy	41.45±1.48	22.08±1.10	−19.38±1.84	Very high
	Nonscorable bruises	28.43±0.90	27.01±1.19	−1.42	—
	Nonscorable lesions	22.00±0.88	32.62±1.24	+10.62±1.52	Very high
	2 preceding	50.45±1.32	59.63±1.10	+9.18±1.72	1350+:1
	Scorable bruises	5.21±0.29	9.89±0.50	+4.62±0.59	Very high
	Scorable lesions	2.73±0.36	7.81±0.58	+5.08±0.68	Very high
	Scorable lesions with soft rot	0.10±0.06	0.02±0.19	+0.52	—
	3 preceding	8.11±0.55	18.29±0.70	+10.18±0.89	Very high

[1] See Table 1 for certain data on each stock.
[2] Each tuber was placed as far down the scale as possible. "Nonscorable" and "Scorable" according to inspectors' standards: lesions nonscorable up to ⅛ inch in diameter.
[3] Mean of percentage by weight, for 10 fifty-pound bags, which consisted of tubers in the condition specified.
[4] New York percentage over or under Maine percentage.
[5] If under 30:1, not significant and not given.

Two similar stocks (49-S and 49-U) of the 1949 crop were sampled. Data are presented in Table 6. Similar results were obtained. It is apparent that this kind of "cleaning" does not make such stock suitable for shipment.

In shipments from Oregon to Chicago (*1*, p.26), it was found that the development and spread of soft rot may be rapid even under refrigeration. Hundred-pound sacks with an average of 0.8 pound of tubers with this disease at shipping point had 7.7 pounds at unloading point.

ABSENCE OF CHANGE AFTER WASHING

Two 50-pound bags of Katahdin tubers (stock 49-T) were taken from a washer at Aroostook Farm and placed in a car preheated to about 90° F. Shipment was made in the same car, in which the average

transit temperature was 47°. Some bruises and lesions were encircled with pencil marks. In New York, there was no apparent change; the color was as bright as when shipped, bruises and lesions did not increase, and there was no new decay.

NET NECROSIS AND STEM-END BROWNING

Small-scale sampling of potatoes of the 1939 crop by the inspection service and shipment to several cities yielded data which showed no consistent effect of transit conditions on net necrosis and stem-end browning (*6*, p. 1031). About 1100 barrels (3025 bushels) of potatoes from the 1940, 1941, 1942, 1943, and 1945 crops were stored in bins at Aroostook Farm with the temperature controlled (*6*). Examination of these showed that net necrosis and stem-end browning were influenced greatly by storage temperature. Development of both diseases was favored most by a temperature of 45 to 50° F., reaching a peak within two or three months after harvesting. However, storage at 33° for 60 days after digging changed the tubers so that no increase in these two diseases occurred later at any temperature. Therefore, it was to be expected that the increase in these diseases during shipment would vary, depending upon length of time since harvesting, the storage temperature previous to shipment, and temperature in transit.

Crop of 1947

The authors took 100-pound samples from three stocks of the 1947 crop. Each tuber was examined for both net necrosis and stem-end browning and classified as healthy, slightly affected (up to five per cent waste from removal of affected tissue), moderately affected (5 to 10 per cent waste), or severely affected (more than 10 per cent waste). Most of the bags were quartered, with records for the tubers in each quarter bag kept separate to determine the relative value of 25-, 50-, and 100-pound samples from the same stock. An additional (triplicate) series from each stock was stored in New York at room temperature to obtain the effect of conditions in a store. Shipment was made in late February at 43 to 50° in transit. The temperature in New York storage was 65°.

An analysis of the 1947 crop results showed that 100-pound samples yielded more differences that were significant than did 50- or 25-pound samples. The use of Student's method increased the number of differences that were significant. The data showed that the percentages of Green Mountain and Irish Cobbler stock affected with stem-end browning did not change in transit or in New York storage, but that

TABLE 7

Comparison of Maine and New York Readings on Stem-End Browning and Net Necrosis

Stock[1]	Disease[2]	Wastage	Percentage[3] in		Difference[4]	Approximate odds[5]
			Maine	New York		
48–A	None	None	55.7±1.8	56.5±2.1	+0.8	—
	SEB	0–5%	14.1±1.5	14.8±1.3	+0.7	—
	SEB	5–10%	6.0±0.7	3.3±0.4	−2.7	43:1
	SEB	10+%	24.1±1.3	25.5±1.6	+1.4	—
48–B[6]	None	None	52.2±1.8	54.2±1.8	+2.0	—
	SEB	0–5%	23.8±1.1	21.9±1.2	−1.9	—
	SEB	5–10%	5.9±1.1	3.3±0.4	−2.6	—
	SEB	10+%	4.7±0.7	9.1±0.9	+4.4	142:1
	NN	10+%	13.4±1.2	11.7±1.1	−1.7	—
48–D	None	None	64.2±1.6	62.9±2.1	−1.3	—
	SEB	0–5%	17.9±1.1	20.9±1.6	+3.0	—
	SEB	5–10%	4.9±0.8	5.8±0.6	+0.9	—
	SEB	10+%	12.9±1.2	10.5±1.2	−2.4	—
48–E[6]	None	None	51.7±0.6	49.1±0.7	−2.6	—
	SEB	0–5%	20.1±0.6	22.5±0.8	+2.4	—
	SEB	5–10%	8.5±0.3	8.6±0.5	+0.1	—
	SEB	10+%	7.9±0.4	8.1±0.5	+0.2	—
	NN	10+%	12.0±0.7	11.9±0.5	−0.1	—
48–F	None	None	57.5±1.3	48.1±1.0	−9.4±1.6	1350+:1
	SEB	0–5%	29.0±1.3	29.6±1.7	+0.6	—
	SEB	5–10%	6.9±0.8	10.7±0.8	+3.8±1.1	49:1
	SEB	10+%	0	2.5±0.6	+2.5±0.6	216:1
	NN	10+%	6.8±0.9	9.1±0.7	+2.3	—
48–H	None	None	69.1±1.2	67.7±1.5	−1.4	—
	SEB	0–5%	24.0±1.3	23.3±1.5	−0.7	—
	SEB	5–10%	2.5±0.5	4.7±0.5	+2.2	—
	SEB	10+%	0	1.9±0.5	+1.9±0.5	95:1
	NN	10+%	4.3±0.8	2.4±0.4	−1.9±0.5	95:1
49–C	None	None	46.88±2.11	44.64±1.95	−2.24	—
	NN	0–5%	11.46±1.36	13.63±1.12	+2.17	—
	NN	5–10%	11.63±0.80	13.41±0.85	+1.78	—
	NN	10+%	30.06±0.61	28.31±1.14	−1.75	—
49–D	None	None	76.89±0.87	76.12±0.53	−0.77	—
	NN	0–5%	11.60±0.52	9.51±0.43	−2.09	—
	NN	5–10%	2.76±0.23	4.47±0.34	+1.71±0.41	200:1
	NN	10+%	8.71±0.60	9.92±0.60	+1.21	—
49–E	None	None	52.48±1.05	25.77±0.72	−26.71±1.27	Infinite
	NN	0–5%	18.19±0.92	8.92±0.47	−9.27±1.03	Infinite
	NN	5–10%	6.50±0.44	16.99±1.10	+10.49±1.18	Infinite
	NN	10+%	22.82±0.69	48.33±1.41	+25.51±1.57	Infinite
49–F	None	None	74.17±1.00	76.87±0.96	+2.70	—
	SEB	0–5%	18.29±0.89	10.63±0.56	−7.66±1.05	400,000+:1
	SEB	5–10%	4.23±0.29	6.5±0.42	−2.33±0.51	480:1
	SEB	10+%	3.31±0.40	5.94±0.53	+2.66±0.65	140:1
49–G	None	None	34.79±0.65	11.69±0.45	−23.10±0.79	Infinite
	NN	0–5%	14.09±0.80	10.06±0.74	−4.03±1.09	85:1
	NN	5–10%	15.40±0.57	17.69±0.65	+2.29	—
	NN	10+%	35.70±1.14	60.64±0.84	+24.94±1.42	Infinite
49–H	None	None	39.76±1.82	39.92±1.83	−0.16	—
	NN	0–5%	13.29±0.56	9.75±0.89	−3.54±1.05	49:1
	NN	5–10%	17.41±0.53	14.17±0.79	−3.24±0.95	45:1
	NN	10+%	29.53±0.70	36.16±1.18	+6.63±1.37	850:1
49–M	None	None	58.02±1.01	85.80±0.73	+27.78±1.25	Infinite
	NN	0–5%	12.46±0.74	0.20±0.09	−12.26±0.75	Infinite
	NN	5–10%	12.72±0.57	0.75±0.20	−11.97±0.69	Infinite
	NN	10+%	16.82±0.80	13.25±0.79	−3.57±1.12	31:1

TABLE 7—(Concluded)

Stock[1]	Disease[2]	Wastage	Percentage[3] in		Difference[4]	Approximate odds[5]
			Maine	New York		
49–N	None	None	51.38±0.73	50.06±1.16	—1.32	—
	NN & SEB	0–5%	35.13±0.48	28.70±1.15	—6.43±1.25	1350+:1
	NN & SEB	5–10%	5.18±0.39	8.11±0.53	+2.93±0.66	360:1
	NN & SEB	10+%	8.32±0.53	13.12±0.99	+4.80±1.12	265:1
49–Q	None	None	71.05±0.66	72.04±0.65	+0.99	—
	NN	0–5%	11.82±0.63	8.23±0.54	—3.59±0.83	290:1
	NN	5–10%	7.35±0.53	7.58±0.48	+0.23	—
	NN	10+%	9.80±0.36	12.15±0.41	+2.35±0.55	250:1
49–R	None	None	79.12±1.09	78.89±1.06	—0.23	—
	NN	0–5%	9.09±0.55	7.03±0.61	—2.06	—
	NN	5–10%	5.49±0.59	6.23±0.51	+0.74	—
	NN	10+%	6.29±0.56	7.74±0.62	+0.45	—
49–V	None	None	78.55±0.62	80.48±1.23	+1.93	—
	NN	0–5%	9.23±0.54	6.84±0.47	—2.39±0.72	39:1
	NN	5–10%	5.34±0.43	6.46±0.52	+1.12	—
	NN	10+%	6.87±0.64	6.24±0.61	—0.63	—
49–Y	None	None	81.75±0.66	81.00±0.60	—0.75	—
	NN	0–5%	2.75±0.31	2.87±0.32	+0.12	—
	NN	5–10%	4.20±0.57	4.43±0.33	+0.23	—
	NN	10+%	11.30±0.59	11.68±0.64	+0.38	—

[1] See Table 1 for certain data on each stock.
[2] NN indicates net necrosis and SEB, stem-end browning.
[3] Mean of percentage by weight, for 10 to 15 bags, consisting of tubers in the specified condition.
[4] New York percentage over or under Maine percentage.
[5] If under 30:1, not significant and not given.
[6] From same binful of potatoes, but from different parts and at different times.

the severity of stem-end browning increased in transit and decreased in New York storage. The changes in percentage of stock affected with net necrosis (all severe) were all increases in transit and in storage, but were not significant.

Crop of 1948

To find net necrosis and stem-end browning in the 1948 crop, the second author examined test samples from 149 Green Mountain bins in 28 localities in Aroostook County, from December 28 to February 11. Net necrosis was absent from 140 bins, was present in trace amounts in four bins, and was in 3 to 13 per cent of the individual tubers in five bins. Stem-end browning was negligible except in a few stocks. Five stocks were sampled. The results are presented in Table 7. Judging from the disease-free percentages, only one stock (48-F) showed much increase in disease; it showed greater difference in net necrosis (+2.3%) and in total stem-end browning (+6.9%) than any other stock.

Crop of 1949

Net-necrosis samples were much easier to find in the 1949 crop than in the 1948 crop. The resulting data on net necrosis and stem-end

browning are given in Table 7. In stock 49-F, there was no increase in percentage showing stem-end browning, but there was a significant increase in severity. In stock 49-N, where it was difficult to distinguish between net necrosis and stem-end browning, there was no significant increase in percentage of stock showing the two diseases, but there was a significant increase in severity. In stock 49-M, where the net necrosis was of a light type, possibly due to a vine-killing chemical, there was a very significant decrease in percentage of stock showing the defect and also a significant decrease in severity. The other nine stocks except 49-E and 49-G (Table 8) showed no percentage increase but in five

TABLE 8

Changes in Net Necrosis in Nine Series of Table 7

Stock	Shipping date	Mean temperature in transit	Summary of changes in net necrosis
		°F.	
49–C	Nov. 26	42	No great and no significant change in percentage or severity
49–D	Nov. 28	47	No significant percentage increase, but severity increase, some significant
49–E	Nov. 28	47	Large and very significant increase in percentage and severity
49–G	Dec. 17	42	Ditto
49–H	Dec. 17	42	No percentage increase, but significant severity increase
49–Q	Feb. 16	50	Ditto
49–R	Feb. 16	50	No percentage increase, but some severity increase
49–V	Mar. 23	45	No percentage increase, and no significant severity increase
49–Y	Mar. 28	43	No great and no significant change in percentage or severity

instances showed significant severity increase. Here there was no apparent relation of percentage increase or severity increase to month of shipment or average temperature in transit, except that increases were least in March. It is noteworthy that the percentage healthy was reduced by half in stock 49-E and by two-thirds in stock 49-G, and that the percentage with severe net necrosis was about doubled in both these stocks.

MAHOGANY BROWNING

Crop of 1947

Mahogany browning appeared in stored Chippewa and Katahdin stocks in 1948 about April 1, as in previous years. Carloads inspected and passed at shipping time were showing higher percentages of the defect when inspected at destination. This defect had been shown (*5, 9*) to result from holding tubers of certain varieties for several months at near-freezing temperatures. Chippewa samples of the 1943 crop stored at 32° F. for 62, 90, 121, and 150 days after digging developed the de-

fect in 0, 3, 36, and 97 per cent of the tubers respectively (Maine Agr. Exp. Sta. Bul. 426, Table 35). Therefore it was not surprising that mahogany browning in commercial storage did not begin to cause trouble until late March in 1948.

The defect occurred in 1948 in bins that were below ground level except for the top few feet and occurred from top to bottom in a narrow zone next to or close to an outside concrete wall. Often the concrete wall was near a railroad track where the snow had been kept cleared off. It seems reasonable to suppose that during the unusually cold winter too much heat had been lost by the tubers next to the concrete wall, which was an efficient conductor of heat to the outside air in contact with the upper part of the wall. In one instance the tubers within about 18 inches of the wall had frozen and become leakers, while the tubers 18 inches to three feet from the wall showed only mahogany browning.

Incidentally, it was possible to pack healthy stock from such bins by eliminating the tubers close to the wall.

Samples were taken in early April, 1948, from five stocks of the 1947 crop. The tubers of each bagful were examined in the order of decreasing size. Every tuber was sliced up enough for the examiner to estimate the approximate percentage of tissue affected by mahogany browning. All affected tubers in a bag were weighed together as were all healthy tubers. The records obtained were used to give for each bag:

Percentage by weight affected with mahogany browning
Percentage of tubers affected with mahogany browning
Percentage of the larger tubers affected with mahogany browning
Percentage of the smaller tubers affected with mahogany browning
Of affected tubers in each bag, the percentage with 1-20, 21-40, 41-60, 61-80, 81-100% of tissue affected
Average weight of all tubers
Average weight of affected tubers
Average % of tissue affected in affected tubers
Average % of tissue affected in all tubers
Percentage of bag weight consisting of mahogany browning tissue

Having these results for each bag, the series of bags were then compared statistically to determine:

Prevalence (percentage by tuber number) of mahogany browning as affected by tuber size
Prevalence of mahogany browning as affected by transit
Amount (percentage by weight) of affected stock in relation to tuber size
Amount as affected by transit
Severity (percentage of tissue or tuber flesh darkened by mahogany browning) as affected by tuber size
Severity as affected by transit

In addition to the two basic series of samples from each stock examined at the shipping point and in New York on arrival, other parallel series of samples were held in the following storages:

Aroostook Farm at 36° F. for a month
Aroostook Farm at 47° F. for a month
Aroostook Farm at 67° F. for a month
New York at about 67° F. for two weeks after arrival

TABLE 9

Comparison of Maine and New York Readings on Mahogany Browning in the 1948 Crop

Characteristic	Stock[1]	Bag mean[2] Maine	Bag mean[2] New York	Difference[3]	Approximate odds[4]
Average tuber weight (in lb.)	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	—
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—
Percentage by weight consisting of affected tubers	48-J	[illegible]	[illegible]	[illegible]	53:1
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	[illegible]
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—
Percentage by number consisting of affected tubers	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	66:1
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—
Average weight in lb. of affected tubers	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	—
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	—	—
Percentage of flesh affected, average per tuber	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	54:1
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	—
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—
Percentage of flesh affected, average per affected tuber	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	—
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—
Percentage of flesh affected in whole bagful	48-J	[illegible]	[illegible]	[illegible]	—
	48-K	[illegible]	[illegible]	[illegible]	—
	48-L	[illegible]	[illegible]	[illegible]	—
	48-M	[illegible]	[illegible]	[illegible]	—
	48-N	[illegible]	[illegible]	[illegible]	—
	48-O	[illegible]	[illegible]	[illegible]	—

[1] See Table 1 for certain data on each stock.
[2] Mean of 15 bag averages.
[3] New York mean over or under Maine mean.
[4] If under 30:1, not significant and not given.

The data showed that the percentage of total tubers affected with mahogany browning increased significantly in transit, as it did in storage at 47° and at 67°. The increase was less at 67° than at 47°. In the affected tubers alone, the percentage of affected tissue increased in transit, in storage at 36°, and in storage at 47°, but increased less at 67° than at 36 or 47°. It decreased in New York storage at 67°. Considering all tubers, the percentage of affected tissue increased in transit and in storage at 47°, increased less at 67° than at 36 or 47°, and decreased in the New York storage at 67°. With greater tuber size, there was a higher percentage of affected tubers and a higher percentage of tissue or flesh affected in the affected tubers. Mahogany browning occurred in all parts of the tuber.

Crop of 1948

Six stocks of the crop of 1948 were sampled in early May and the samples were in transit in the same car, with an average transit temperature of 58° F., for nine days. Charts (Fig. 1) were used in estimating the percentage of tuber flesh discolored by mahogany browning. A summary of the data is presented in Table 9. In general there was an increase during transit in prevalence and amount of mahogany browning. Three of the increases were significant. There were in-

TABLE 10

Effect of Tuber Weight on Prevalence of Mahogany Browning in the Crop of 1948

Stock	Place	Average weight of all tubers[1]	Average weight of affected tubers[2]	Difference[3]	Odds[4]
		lb.	lb.		
48–J	Maine	.375±.006	.394±.009	+.019	—
	New York	.371±.007	.409±.009	+.038	—
48–K	Maine	.397±.007	.474±.021	+.077±.022	54:1
	New York	.413±.007	.481±.024	+.068	—
48–L	Maine	.487±.014	.465±.044	−.022	—
	New York	.485±.010	.531±.028	+.046	—
48–M	Maine	.497±.011	.558±.015	+.061±.019	31.5:1
	New York	.544±.012	.602±.011	+.058±.016	65:1
48–N	Maine	.351±.006	.373±.010	+.022	—
	New York	.360±.007	.383±.008	+.023	—
48–O	Maine	.361±.006	.355±.006	−.006	—
	New York	.347±.005	.355±.008	+.008	—

[1] Same data as in first section of Table 9.
[2] Same data as in fourth section of Table 9.
[3] The 12 differences, according to Student's method, together give odds of 525:1, which are highly significant.
[4] If under 30:1, not significant and not given.

creases in severity (percentage of flesh affected), that in one stock being significant. Since there was a general decrease in severity (percentage of flesh browned) in tubers with mahogany browning, the general increase was due more to the development of the disease in tubers healthy at the first sampling than to the extension of browning in tubers already affected.

In 10 of the 12 series of samples, the average weight per tuber with mahogany browning was greater than that for all tubers. The differences were significant in three series and the mean difference for the 12 series was highly significant (Table 10). The differences would be greater if affected tubers were compared with healthy. In all 12 series the larger tubers showed greater prevalence and severity of mahogany browning than the smaller tubers (Table 11). The differences were highly significant.

TABLE 11

Effect of Relative Apparent Tuber Size on Prevalence and Severity of Mahogany Browning in the 1948 Crop

Stock[1]	Place	Tubers affected[2]		Tuber flesh affected[2]	
		Larger tubers[3]	Smaller tubers[4]	Larger tubers[3]	Smaller tubers[4]
		Per cent	Per cent	Per cent	Per cent
48-J	Maine	63.5	49.3	9.7	7.3
	New York	73.5	54.8	13.1	7.6
48-K	Maine	38.2	8.8	1.6	0.9
	New York	20.4	17.3	2.0	1.3
48-L	Maine	38.5	23.0	12.0	4.8
	New York	37.1	21.4	11.4	5.5
48-M	Maine	60.4	47.2	15.7	10.7
	New York	72.7	30.4	19.5	13.3
48-N	Maine	55.4	42.0	28.0	18.7
	New York	63.4	47.1	27.4	19.2
48-O	Maine	46.1	42.8	25.2	21.4
	New York	52.6	48.7	26.5	24.5

[1] See Table 1 for certain data on each stock.
[2] Differences over ones: by Student's method that the difference was significant in each of the two [illegible].
[3] Larger tubers were the 25% apparently largest tubers in each bag, those of all bags being combined for each bag series.
[4] Smaller tubers were the 25% apparently smallest tubers in each bag, those of all bags being combined for each bag series.

Crop of 1949

One stock of the crop of 1949 was sampled in late March and five stocks were sampled in late April. The samples were shipped at an average transit temperature of 43 to 44° F. The summarized data are presented in Table 12. In general, as in the crop of 1948, there was a

TABLE 12

Comparison of Maine and New York Readings on Mahogany Browning in the 1949 Crop

Characteristic	Stock[1]	Bag mean[2]		Difference[3]	Approximate odds[4]
		Maine	New York		
Average tuber weight (in lb.)	49–Z	.403±.008	.383±.012	−.020	—
	49–AA	.363±.007	.376±.009	+.013	—
	49–BB	.495±.014	.485±.011	−.010	—
	49–CC	.450±.015	.411±.011	−.039	—
	49–DD	.387±.009	.373±.011	−.014	—
	49–EE	.415±.012	.423±.010	+.008	—
Percentage by weight consisting of affected tubers	49–Z	78.7±3.2	72.3±3.5	−6.4	—
	49–AA	59.5±2.4	72.1±1.7	+12.6±2.9	300:1
	49–BB	69.1±5.9	77.5±3.6	+8.4	—
	49–CC	56.8±2.7	55.1±2.7	−1.7	—
	49–DD	26.7±2.8	41.3±2.8	+14.6±4.0	71:1
	49–EE	31.5±2.6	58.3±2.9	+26.8±3.9	400,000:1
Percentage by number consisting of affected tubers	49–Z	74.2±3.1	68.4±3.6	−5.8	—
	49–AA	57.3±2.4	67.7±1.7	+10.4±2.9	50:1
	49–BB	68.9±5.8	75.5±3.0	+6.6	—
	49–CC	54.8±2.9	52.1±2.5	−2.7	—
	49–DD	21.4±2.3	36.0±2.5	+15.6±3.4	510:1
	49–EE	29.9±2.8	53.1±2.7	+13.2±3.9	43:1
Average weight (in lb.) of affected tubers	49–Z	.431±.009	.411±.013	−.020	—
	49–AA	.379±.006	.401±.009	+.022	—
	49–BB	.500±.018	.499±.015	−.001	—
	49–CC	.481±.018	.431±.011	−.050	—
	49–DD	.511±.030	.433±.017	−.078	—
	49–EE	.459±.023	.468±.013	+.009	—
Percentage of flesh affected, average per tuber	49–Z	46.0±2.6	42.1±2.5	−3.9	—
	49–AA	16.7±0.9	19.3±0.8	+2.6	—
	49–BB	26.8±3.3	40.4±3.0	+13.6	—
	49–CC	28.5±2.1	30.7±2.4	+2.2	—
	49–DD	4.0±0.7	5.0±0.8	+1.0	—
	49–EE	6.2±0.6	9.1±0.9	+2.9	—
Percentage of flesh affected, average per affected tuber	49–Z	60.3±1.6	56.0±2.5	−4.3	—
	49–AA	29.6±1.3	28.6±1.1	−1.0	—
	49–BB	31.5±3.2	46.9±4.5	+15.4	—
	49–CC	51.3±2.1	56.5±2.5	+5.2	—
	49–DD	16.7±1.4	12.5±1.3	−4.2	—
	49–EE	21.3±1.8	16.5±0.9	−4.8	—
Percentage of flesh affected in whole bagful	49–Z	48.5±2.7	42.6±3.0	−3.9	—
	49–AA	17.3±0.9	20.5±0.9	+3.2	—
	49–BB	26.8±3.3	41.1±5.0	+14.3	—
	49–CC	29.5±2.1	32.7±2.7	+3.2	—
	49–DD	4.9±0.8	5.6±0.8	+0.7	—
	49–EE	6.5±0.6	10.1±1.0	+3.6	—

[1] See Table 1 for certain data on each stock.
[2] Mean of 15 fifteen-pound bag averages.
[3] New York mean over or under Maine mean.
[4] If under 30:1, not significant and not given.

transit increase in prevalence of mahogany browning with six of the increases significant. There was also an increase in severity (percentage of flesh affected). A consistent exception to this conclusion is stock 49-Z, the one sampled a month ahead of the others.

Twelve series of samples were taken from the six stocks. In most of these series, the average weight per tuber with mahogany browning was significantly more than that for all tubers (Table 13). The larger

TABLE 13

Effect of Tuber Weight on Prevalence of Mahogany Browning in the 1949 Crop

Stock	Place	Average weight of all tubers[1]	Average weight of affected tubers[2]	Difference[3]	Odds[4]
		Lbs.	Lbs.		
49–Z	Maine	.403±.006	.431±.009	+.028	134:1
	New York	.383±.012	.411±.013	+.028	529:1
49–AA	Maine	.363±.007	.379±.006	+.016	2339:1
	New York	.376±.009	.401±.009	+.025	9999:1
49–BB	Maine	.495±.014	.500±.018	+.005	—
	New York	.485±.011	.499±.015	+.014	—
49–CC	Maine	.430±.015	.481±.018	+.031	—
	New York	.411±.011	.431±.011	+.020	85:1
49–DD	Maine	.387±.009	.511±.030	+.124	233:1
	New York	.373±.011	.433±.017	+.060	6999:1
49–EE	Maine	.415±.012	.459±.023	+.044	50:1
	New York	.423±.010	.468±.013	+.045	4999:1

[1] Same data as in first section of Table 12.
[2] Same data as in fourth section of Table 12.
[3] The 12 differences, according to Student's method, together give odds of 1110:1 which are highly significant.
[4] By Student's method. If under 30:1, not significant and not given.

TABLE 14

Effect of Relative Apparent Tuber Size on Prevalence and Severity of Mahogany Browning in the 1949 Crop

Stock[1]	Place	Tubers affected[2]		Tuber flesh affected[2]	
		Larger tubers[3]	Smaller tubers[4]	Larger tubers[3]	Smaller tubers[4]
		Per cent	Per cent	Per cent	Per cent
49–Z	Maine	58.6	60.5	35.2	37.5
	New York	73.3	64.2	47.5	36.4
49–AA	Maine	63.3	52.1	16.5	16.8
	New York	78.8	58.8	23.2	22.4
49–BB	Maine	72.6	68.4	30.3	25.8
	New York	80.8	73.1	44.1	38.6
49–CC	Maine	62.2	47.7	36.0	21.9
	New York	62.0	45.3	30.2	23.8
49–DD	Maine	27.7	18.5	5.4	3.5
	New York	45.3	30.7	7.2	4.2
49–EE	Maine	36.8	24.8	7.9	5.1
	New York	64.7	41.6	11.3	7.4

[1] See Table 1 for certain data on each stock.
[2] Odds by Student's method over 9999:1 for prevalence, and 649:1 for severity, that the difference was significant.
[3] Larger tubers were the 50% apparently largest tubers in each bag, those of all bags being combined for each bag series.
[4] Smaller tubers were the 50% apparently smallest tubers in each bag, those of all bags being combined for each bag series.

tubers showed greater prevalence of mahogany browning in all 12 series and greater severity in 11 series (Table 14). These two differences were highly significant.

WEIGHT SHRINKAGE IN TRANSIT

A comparison of the weight of samples examined in Maine with the weight of those examined in New York for the 1949 crop is shown in Table 15. The average weight of the 50-pound bags was 49.20

TABLE 15

Weight of Contents of Intended 50-Pound Bags in Maine and New York

Stock[1]	Weight of contents per bag		Difference[2]
	In Maine	In New York	
	Lbs.	Lbs.	Lbs.
49–A	49.85	49.10	—0.75
49–C	50.18	49.30	—0.88
49–D	49.58	49.23	—0.35
49–E	48.85	47.80	—1.05
49–F	48.40	46.78	—1.62
49–G	50.03	49.48	—0.55
49–H	50.23	49.25	—0.98
49–I	49.30	47.65	—1.65
49–J	49.30	49.38	+0.08
49–K	48 48	48.58	+0.10
49–L	49.08	47.78	—1.30
49–M	50.35	49.28	—1.07
49–N	49.88	49.58	—0.30
49–O	48.85	47.55	—1.30
49–P	50.03	48.65	—1.38
49–Q	47.75	47.93	+0.18
49–S	47.85	47.60	—0.25
49–U	49.43	47.73	—1.70
49–V	49.20	48.70	—0.50
49–W	48.53	47.78	—0.75
49–X	48.33	48.25	—0.08
49–Y	48.83	48.43	—0.40

[1] See Table 1 for certain data on each stock.
[2] The mean difference (0.75 pound) between the Maine mean (49.20 pounds) and the New York mean (48.45 pounds) was highly significant (odds of over 9999 to 1) according to Student's method.

pounds in Maine and 48.45 pounds in New York in 22 shipments. This amounted to a 1.6 per cent shortage when shipped and a loss of 1.5 per cent in transit. The transit shrinkage was highly significant. Railroad shipments from Oregon to Chicago showed that 103-pound bags shrunk to 101 pounds, or about two per cent (*1*, p. 28, *10*, p. 9). Railroad shipments of 10-ounce potatoes from Idaho to Des Moines and Indianapolis lost 2.2 pounds per hundredweight, or two per cent (*10*, p. 9). In shipments from Alabama to Chicago, 25-pound bags lost two per cent in weight in a van and three to six per cent in an open truck (*16*, p. 3).

DETERIORATION OF STOCK IN TRANSIT

The general trends for changes in transit were as follows. The percentage (by weight) of the sample with late-blight rot, decreased probably because of faster weight shrinkage of affected tubers. In samples containing some late-blight rot, there was an increase in the percentage (by weight) of tubers with (1) late-blight rot and evident fusarium rot, (2) late-blight rot and soft rot, (3) evident fusarium rot only, or (4) soft rot only. Early-blight rot decreased in severity. Ring rot usually increased in prevalence and severity. Bruise cracks, incurred during grading, healed in part and in part became more conspicuous and scorable. Scorable lesions and soft rot increased considerably in stocks containing soft rot that were "cleaned" with rubber brushes and sawdust. Washed tubers showed no change. Net necrosis, stem-end browning, and mahogany browning sometimes increased.

The instance of greatest or most strikingly significant increase in

TABLE 16

Maximum Significant Increases in Transit

Stock[1]	Diseases and injuries	In transit		
		Change	Days	Av. temperature
		Per cent[2]		°F.
49–B	Late-blight and fusarium rot[3]	0.7 to 5.0[4]	7	42
49–P	Late blight and bacterial soft rot	0.2 to 3.1	6	50
49–B	Fusarium rot[3] in late-blight-free tubers of partly late-blight stock	0.3 to 1.0	7	42
49–P	Soft rot in late-blight-free tubers of partly late-blight stock	0.4 to 1.3	6	50
49–A	Ring rot	8 to 11	7	42
48–C	Scorable bruises in stock "cleaned" with rubber brushes and sawdust	5 to 11	8	47
48–C	Scorable lesions in stock "cleaned" with rubber brushes and sawdust	3 to 11	8	47
48–I	Scorable soft-rot lesions in stock "cleaned" with rubber brushes and sawdust	5 to 16	7	51
49–E	Severe net necrosis[5]	23 to 48	8	47
48–B	Severe stem-end browning[5]	5 to 9	6	65
49–EE	Mahogany browning, weight of affected tubers	32 to 58	5	44
49–EE	Mahogany browning, number of affected tubers	30 to 53	5	44

[1] See Table 1 for certain data on each stock.
[2] By weight, portion consisting of affected tubers, except for last item. From Tables 3, 5, 6, 7, 9, and 12.
[3] Fungus growth evident.
[4] Maine and New York readings, respectively.
[5] With over 10 per cent waste in slicing off defect.

each disease or defect is given in Table 16. It seems evident that several kinds of deterioration occurring in transit can cause stocks that are in-grade at shipping point to be out-of-grade at unloading point.

COMPARISON OF CONTROLLED-TEMPERATURE STORAGE TESTS WITH RAILROAD SHIPPING TESTS

As indicated, net necrosis and stem-end browning were studied in controlled-temperature storages pervious to the beginning of the present study. Mahogany browning was studied in controlled-temperature storages as well as in transit in one year in the present study. The results from the two methods are in good agreement. There are certain advantages in using controlled-temperature storages in which samples can be subjected to any desired temperature change by being moved from one storage to another. All of a series of samples will probably be at a more uniform temperature than they would be in a railroad car. The most desirable procedure may be to study a disease or defect thoroughly in controlled-temperature storages and then check in railroad shipments to see whether temperature variation, movement and other transit conditions have additional effects.

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